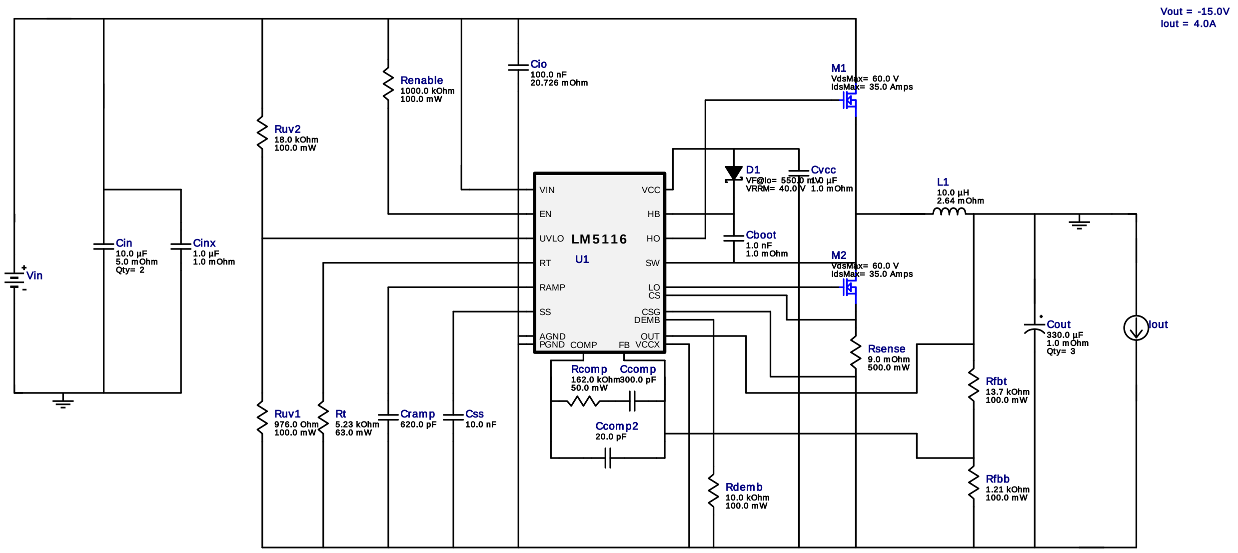
WEBENCH® Design Report

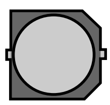
VinMin = 24.0V
VinMax = 30.0V
Vout = -15.0V
Iout = 4.0A

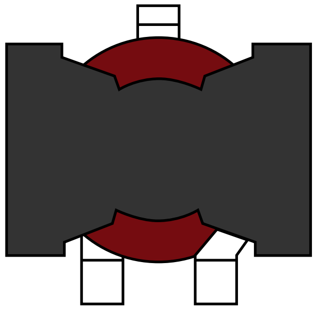
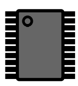
Device = LM5116MH/NOPB
Topology = Inverting_Buck_Boost
Created = 2022-03-17 06:40:59.420
BOM Cost = NA
BOM Count = 27
Total Pd = 2.36W

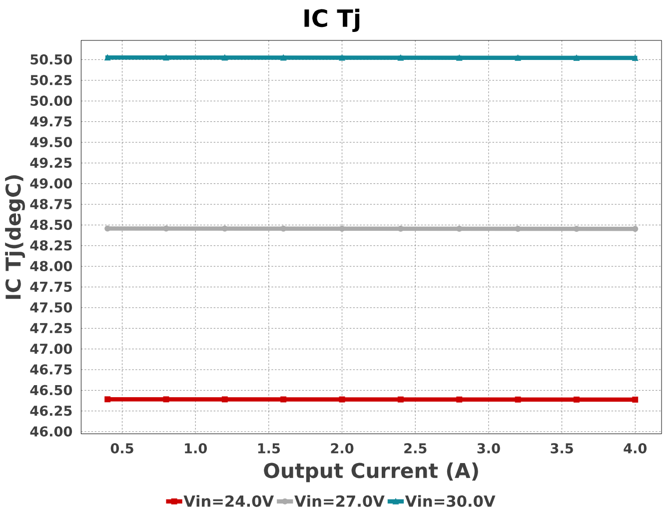
Design : 195 LM5116MH/NOPB
LM5116MH/NOPB 24V-30V to -15.00V @ 4A

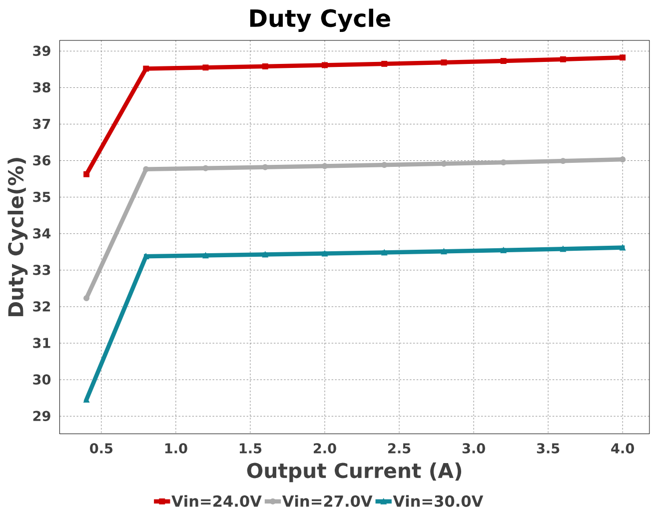


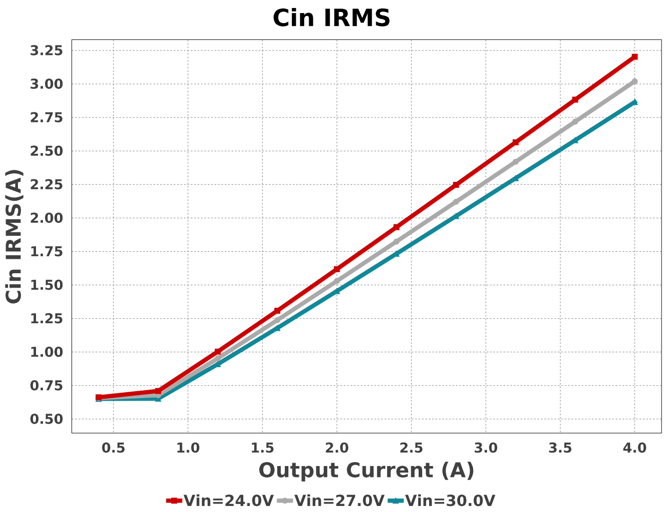
Electrical BOM

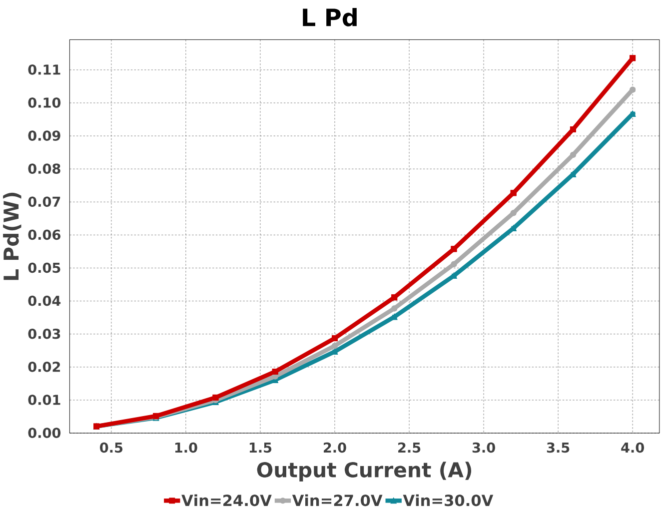
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Kemet	C0603C102K5RACTU Series= X7R	Cap= 1.0 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Ccomp	Samsung Electro-Mechanics	CL10C301JB8NNNC Series= C0G/NP0	Cap= 300.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Ccomp2	Samsung Electro-Mechanics	CL10C200JB8NNNC Series= C0G/NP0	Cap= 20.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Cin	Samsung Electro-Mechanics	CL32B106KBJNNWE Series= X7R	Cap= 10.0 uF ESR= 5.0 mOhm VDC= 50.0 V IRMS= 0.0 A	2	$0.17	1210_270 15 mm^2
Cinx	Taiyo Yuden	TMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Cio	TDK	C2012X7R2A104K125AA Series= X7R	Cap= 100.0 nF ESR= 20.726 mOhm VDC= 100.0 V IRMS= 1.456 A	1	$0.03	0805 7 mm^2
Cout	CUSTOM	CUSTOM Series= ZC	Cap= 330.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 1.6 A	3	NA	 SM_RADIAL_8MM 0 mm^2
Cramp	AVX	06033A621FAT2A Series= C0G/NP0	Cap= 620.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.13	0603 5 mm^2

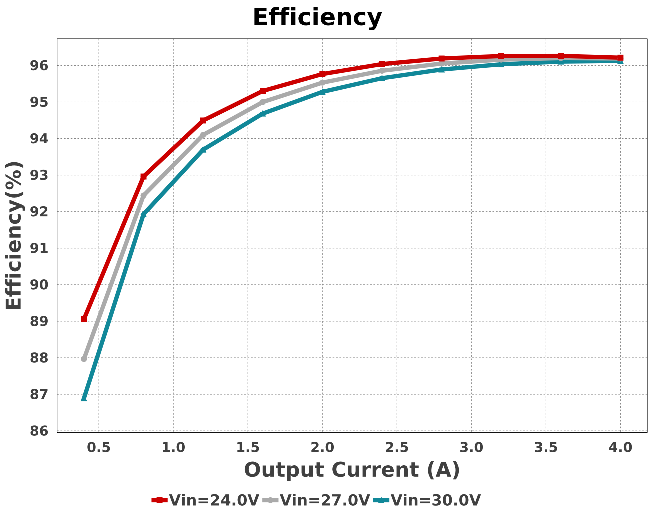
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Css	Samsung Electro-Mechanics	CL10C103JA8NNNC Series= C0G/NP0	Cap= 10.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.05	0603 5 mm^2
Cvcc	Taiyo Yuden	TMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
D1	Fairchild Semiconductor	SS14FL	VF@Io= 550.0 mV VRRM= 40.0 V	1	$0.04	SOD-123F 12 mm^2
L1	Wurth Elektronik	7443641000	L= 10.0 µH 2.64 mOhm	1	$6.83	 WE-HCF_2818 656 mm^2
M1	Texas Instruments	CSD18543Q3A	VdsMax= 60.0 V IdsMax= 35.0 Amps	1	$0.26	DNH0008A 18 mm^2
M2	Texas Instruments	CSD18543Q3A	VdsMax= 60.0 V IdsMax= 35.0 Amps	1	$0.26	DNH0008A 18 mm^2
Rcomp	Yageo	RC0201FR-07162KL Series= ?	Res= 162.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rdemb	Vishay-Dale	CRCW060310K0FKEA Series= CRCW..e3	Res= 10.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Renable	Vishay-Dale	CRCW06031M00FKEA Series= CRCW..e3	Res= 1000.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbb	Vishay-Dale	CRCW06031K21FKEA Series= CRCW..e3	Res= 1.21 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbt	Vishay-Dale	CRCW060313K7FKEA Series= CRCW..e3	Res= 13.7 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rsense	Vishay-Dale	WSL20109L000FEA Series= WSL	Res= 9.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.49	2010 32 mm^2
Rt	Vishay-Dale	CRCW04025K23FKED Series= CRCW..e3	Res= 5.23 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv1	Vishay-Dale	CRCW0603976RFKEA Series= CRCW..e3	Res= 976.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Ruv2	Yageo	RC0603FR-0718KL Series= ?	Res= 18.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LM5116MH/NOPB	Switcher	1	$2.81	 MXA20A 71 mm^2

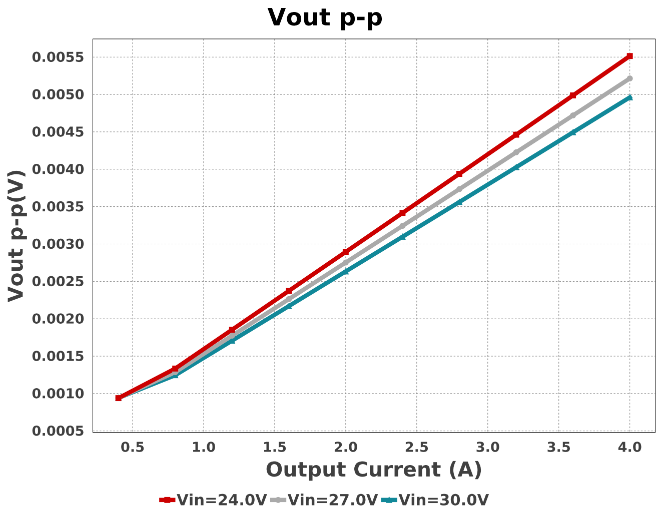

IC Tj
IC Tj(degC)
Output Current (A)
Vin=24.0V Vin=27.0V Vin=30.0V


Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=24.0V Vin=27.0V Vin=30.0V

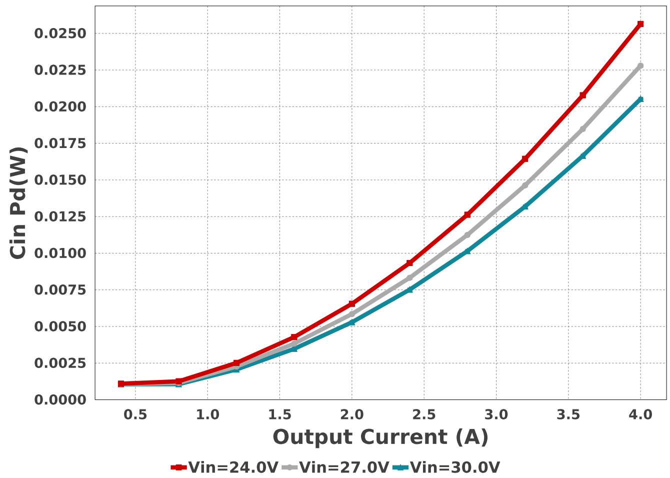

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=24.0V Vin=27.0V Vin=30.0V


L Pd
L Pd(W)
Output Current (A)
Vin=24.0V Vin=27.0V Vin=30.0V

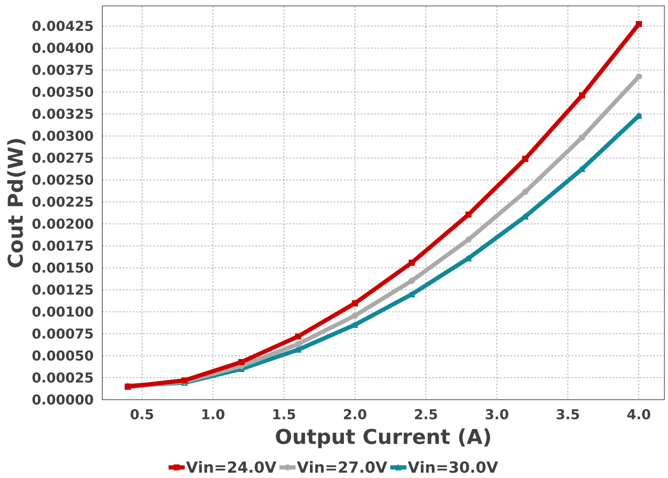

Efficiency
Efficiency(%)
Output Current (A)
Vin=24.0V Vin=27.0V Vin=30.0V


Vout p-p
Vout p-p(V)
Output Current (A)
Vin=24.0V Vin=27.0V Vin=30.0V

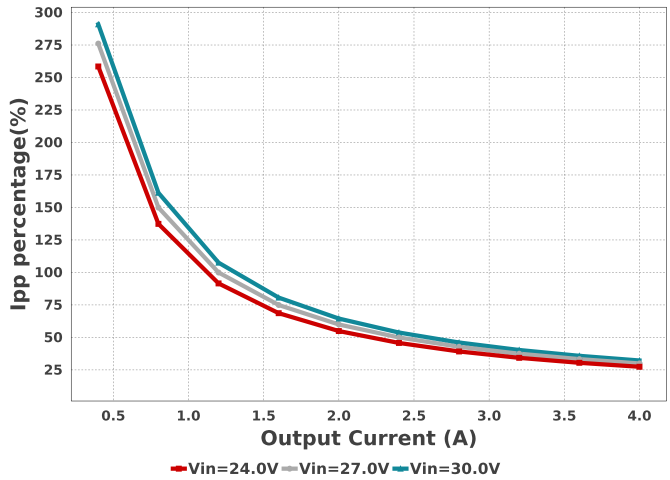
Cin Pd



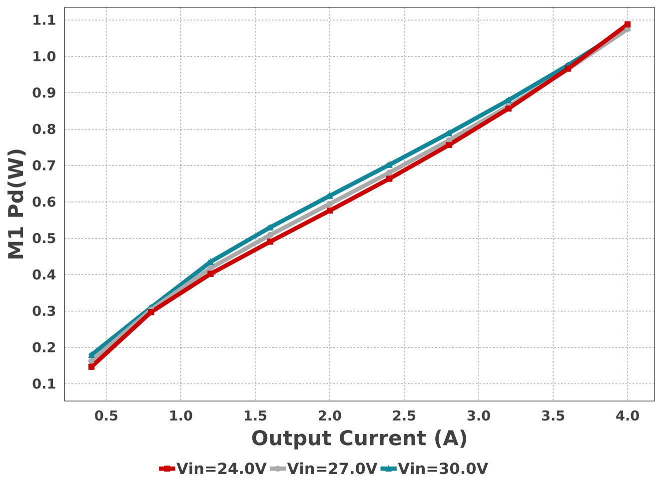
Cout Pd



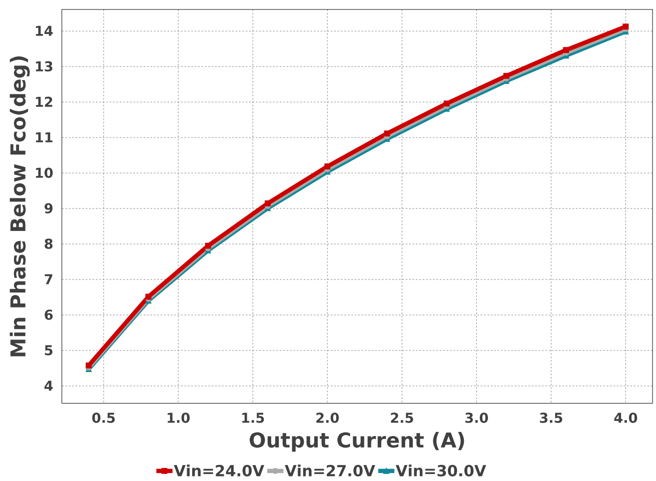
Ipp percentage



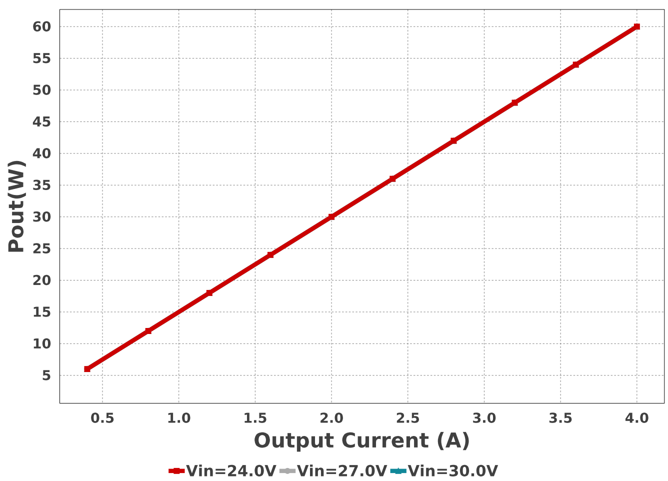
M1 Pd



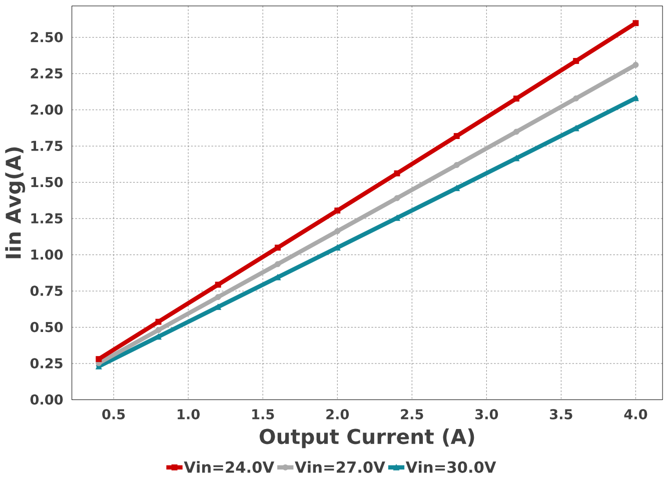
Min Phase Below Fco



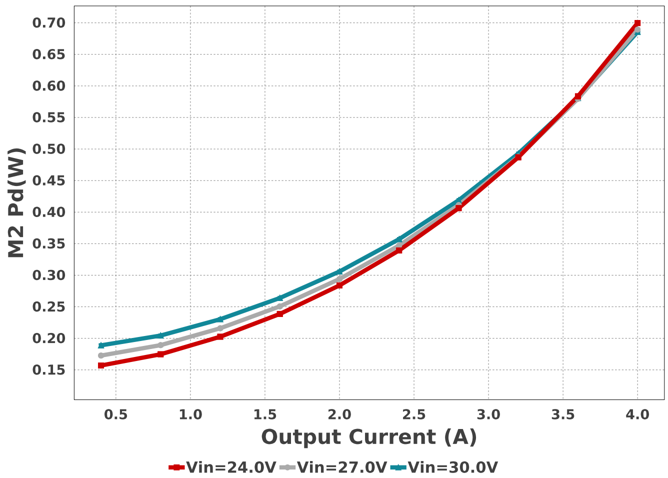
Pout



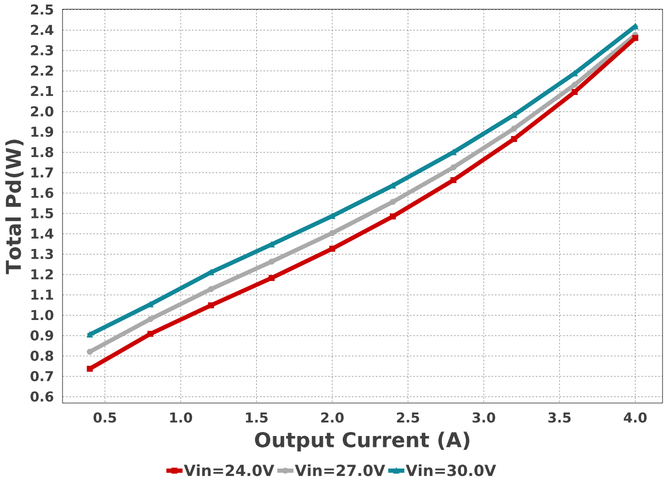
Iin Avg



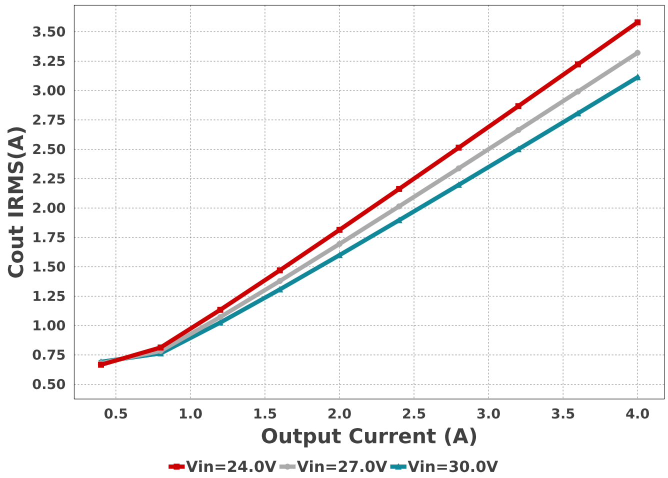
M2 Pd



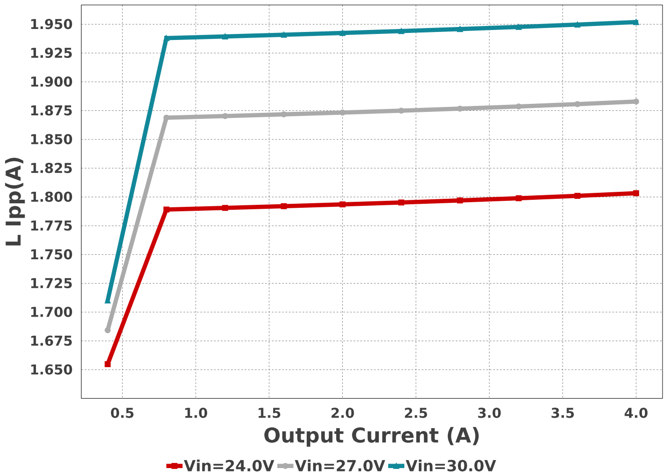
Total Pd



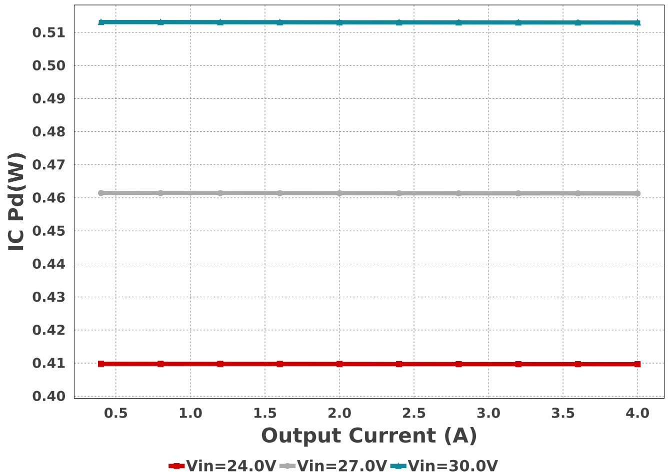
Cout IRMS

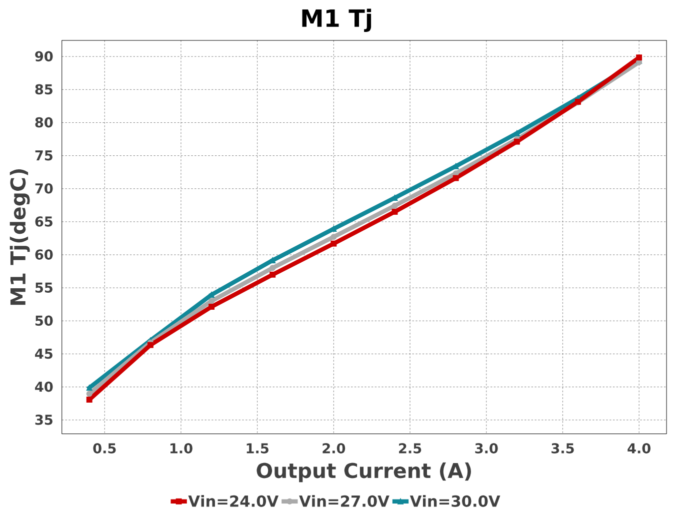


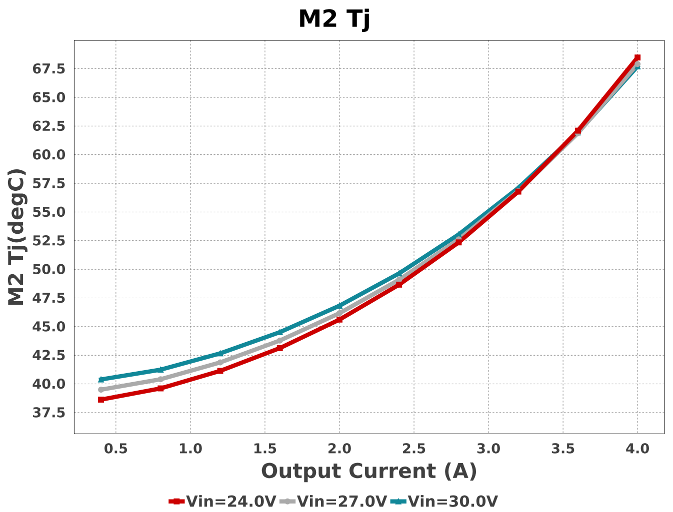
L Ipp

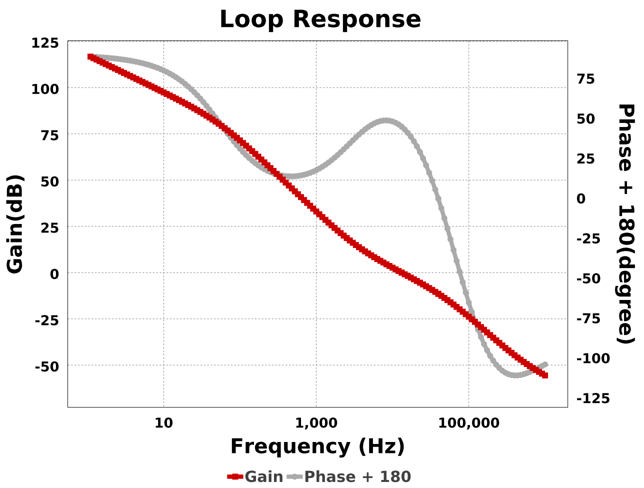


IC Pd









Operating Values

#	Name	Value	Category	Description
1.	BOM Count	27		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	3.203 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	25.644 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	3.58 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	4.273 mW	Capacitor	Output capacitor power dissipation
7.	IC Pd	409.69 mW	IC	IC power dissipation
8.	IC Tj	46.388 degC	IC	IC junction temperature
9.	ICThetaJA	40.0 degC/W	IC	IC junction-to-ambient thermal resistance
10.	Iin Avg	2.598 A	IC	Average input current
11.	Ipp percentage	27.399 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
12.	L Ipp	1.803 A	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	113.57 mW	Inductor	Inductor power dissipation
14.	M1 Pd	1.088 W	Mosfet	M1 MOSFET total power dissipation
15.	M1 Tj	89.852 degC	Mosfet	M1 MOSFET junction temperature
16.	M2 Pd	699.62 mW	Mosfet	M2 MOSFET total power dissipation
17.	M2 Tj	68.479 degC	Mosfet	M2 MOSFET junction temperature
18.	Cin Pd	25.644 mW	Power	Input capacitor power dissipation
19.	Cout Pd	4.273 mW	Power	Output capacitor power dissipation
20.	IC Pd	409.69 mW	Power	IC power dissipation
21.	L Pd	113.57 mW	Power	Inductor power dissipation
22.	M1 Pd	1.088 W	Power	M1 MOSFET total power dissipation
23.	M2 Pd	699.62 mW	Power	M2 MOSFET total power dissipation
24.	Total Pd	2.362 W	Power	Total Power Dissipation
25.	Cross Freq	12.354 kHz	System Information	Bode plot crossover frequency
26.	Duty Cycle	38.824 %	System Information	Duty cycle
27.	Efficiency	96.213 %	System Information	Steady state efficiency

#	Name	Value	Category	Description
28.	FootPrint	1.253 k mm^2	System Information	Total Foot Print Area of BOM components
29.	Frequency	516.71 kHz	System Information	Switching frequency
30.	Gain Marg	-10.246 dB	System Information	Bode Plot Gain Margin
31.	Iout	4.0 A	System Information	Iout operating point
32.	Low Freq Gain	115.676 dB	System Information	Gain at 1Hz
33.	Min Phase Below Fco	14.127 deg	System Information	Minimum Phase Before the Cross-Over Frequency
34.	Mode	CCM	System Information	Conduction Mode
35.	Phase Marg	42.968 deg	System Information	Bode Plot Phase Margin
36.	Pout	60.0 W	System Information	Total output power
37.	Vin	24.0 V	System Information	Vin operating point
38.	Vout	-15.0 V	System Information	Operational Output Voltage
39.	Vout Actual	14.972 V	System Information	Vout Actual calculated based on selected voltage divider resistors
40.	Vout Tolerance	3.198 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
41.	Vout p-p	5.514 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	4.0	Maximum Output Current
VinMax	30.0	Maximum input voltage
VinMin	24.0	Minimum input voltage
Vout	-15.0	Output Voltage
base_pn	LM5116	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature

WEBENCH® Assembly

Component Testing

Some published data on components in datasheets such as Capacitor ESR and Inductor DC resistance is based on conservative values that will guarantee that the components always exceed the specification. For design purposes it is usually better to work with typical values. Since this data is not always available it is a good practice to measure the Capacitance and ESR values of Cin and Cout, and the inductance and DC resistance of L1 before assembly of the board. Any large discrepancies in values should be electrically simulated in WEBENCH to check for instabilities and thermally simulated in WebTHERM to make sure critical temperatures are not exceeded.

Soldering Component to Board

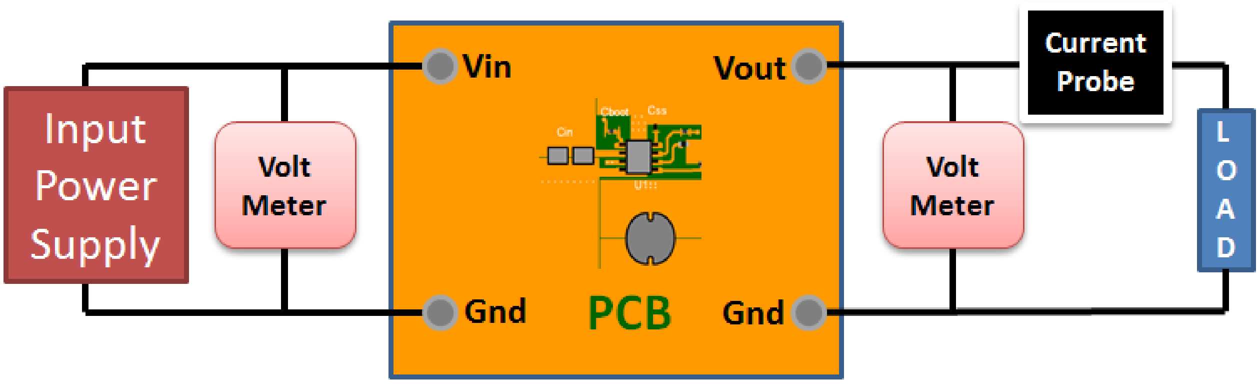
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab town to the board place the iron down on the board while resting against the tab, heating both surfaces simultaneously. Apply light pressure to the top of the plastic case until the solder flows around the part and the part is flush with the PCB. If the solder is not flowing around the board you may need a higher wattage iron (generally 25W to 30W is enough).

Initial Startup of Circuit

It is best to initially power up the board by setting the input supply voltage to the lowest operating input voltage 24.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

Load Testing

The setup is the same as the initial startup, except that an additional digital voltmeter is connected between Vin and GND, a load is connected between Vout and GND and a current meter is connected in series between Vout and the load. The load must be able to handle at least rated output power + 50% (7.5 watts for this design). Ideally the load is supplied in the form of a variable load test unit. It can also be done in the form of suitably large power resistors. When using an oscilloscope to measure waveforms on the prototype board, the ground leads of the oscilloscope probes should be as short as possible and the area of the loop formed by the ground lead should be kept to a minimum. This will help reduce ground lead inductance and eliminate EMI noise that is not actually present in the circuit.



Design Assistance

1. Master key : 000A000D1372BD4C[v1]

2. **LM5116** Product Folder : http://www.ti.com/product/LM5116 : contains the data sheet and other resources.